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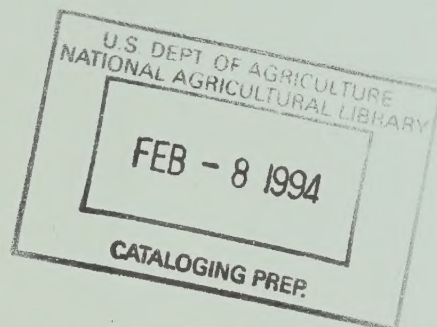
Washington, DC

January 1992



# Change on the Range:

## New Perspectives for Rangeland Research in the 90's



92-15



## Acknowledgements

In July 1990, a team of Forest Service range researchers and rangeland managers convened to develop a list of the major rangeland issues that need to be addressed by Forest Service Research in the 1990's. This team included:

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Many of the ideas included in this team's report were incorporated into this document.

In January 1991, Dr. Richard L. Everett, from the Pacific Northwest Research Station in Wenatchee, Washington, was temporarily assigned to the Forest Environment Research staff in Washington, DC with the goal of preparing this document. This publication was completed because of Rich's dedication to the task. We appreciate his time and his efforts to describe our "New Perspectives for Rangeland Research in the 90's."



# Change on the Range: New Perspectives for Rangeland Research in the 90's

## Introduction

Millions of American citizens live, work, and recreate on rangelands. Public rangelands are an extensive land base held in trust and managed for the public good. They make up over 80 percent of the lands of the 11 western States or approximately 34% (770 million acres) of the United States (Evans 1990). Although it is the 11 western States that are dominated by rangelands, the entire American public has consistently shown its interest in the preservation of wildlands and their species through legislative mandates (Wild Horses and Burros Act of 1971, National Forest Management Act of 1976; Endangered Species Act of 1973 and its amendments, and the Public Rangelands Improvement Act of 1978).

But is our current stewardship of rangelands adequate for the Nineties? Changing lifestyles, economic factors, environmental pressures, increased emphasis on long-term land use planning, and internal efforts to improve procedures have led to a growing public awareness and concern about the management of our Nation's rangelands. Although wildlife, livestock, and water are range products, the land base has its own intrinsic value. The permanent values of rangelands are in the soils and vegetation, and we must protect them. Range science has made significant strides, even with greatly reduced funding, in the last few decades. But a broader focus is needed to meet the challenges of the Nineties.

### Emerging Issues Require A Broader Research Focus

A new perspective in range research is needed to support the Forest Service "Change on the Range" program, to provide required information to sustain rangeland ecosystems, and to provide the desired array of rangeland products and services. Information developed by research outlined in this initiative will help the Forest Service and other land

managers meet the increasing public demand for non-traditional uses of our Nation's public rangelands, in addition to the traditional livestock grazing, while minimizing impacts to the environment.

The ultimate vision of "Change on the Range" is to produce healthy, properly managed ecosystems on all National Forests and Grasslands for wildlife habitat, improved watersheds, and livestock forage. Expanded research is needed to develop technology so that rangelands will contain the appropriate vegetation to protect soil and water, provide riparian and upland habitat for fish and wildlife, respond effectively to management improvements, provide economic benefits, and meet the public desires for open space values. Thus we must develop the technology to support a broader concept of public rangeland management that reflects the multitude of products expected, and demonstrates our ability to sustain rangeland ecosystems for future generations.

### Rangelands: An Arena For Land Use Conflicts

The National Forest System manages 167 million acres of rangeland vegetation in forest, shrub, and grassland settings. Since 1899, when the first livestock permit grazing system was established on Federal Reserve lands, rangelands have been



Livestock can seriously impact limited riparian habitats.



traditionally managed to produce forage for livestock (Comanor 1988). The issue of livestock grazing on public lands has often created conflict among livestock operators and between livestock operators and other resource users.

These concerns and current heightened awareness of environmental issues have caused segments of society to question the ability of the Forest Service to manage public rangelands for multiple resource products and ecosystem preservation (Leroy and Eiguren 1980, McGuire 1977). To preserve future land management options, the Forest Service must find a balance between the sometimes conflicting goals of providing forage, water, wildlife, recreation,

and esthetic values on public rangelands. To achieve this balance requires partnerships with such special-interest groups as the Rocky Mountain Elk Foundation, Trout Unlimited, National Audubon Society, The Nature Conservancy, the Izaak Walton League, and the National Cattleman's Association.

The National Forest System reported to the General Accounting Office (GAO) in May 1990 that over 70% of the range allotments in the six western regions of the National Forests are not in satisfactory condition to meet management objectives. Approximately one fourth of these allotments are declining and overstocked (Figure 1). The unsatisfactory condition of rangelands should not be a surprise, as the budget to maintain them is extremely limited compared to the land base to which it is applied (Figure 2).

The National Forest System has responded to demands for a more holistic management approach with an increased emphasis on all rangeland resources in the "Change on the Range" program initiated in 1989. The Change on the Range Program recognizes that traditional values must be considered, but we must focus on safeguarding basic soil, water, and vegetation resources. Although the Forest Service is committed to the vision of quality rangelands and the process to achieve them (Comanor 1988), new information is required on how rangeland ecosystems can be preserved while providing an array of products for all segments of society.

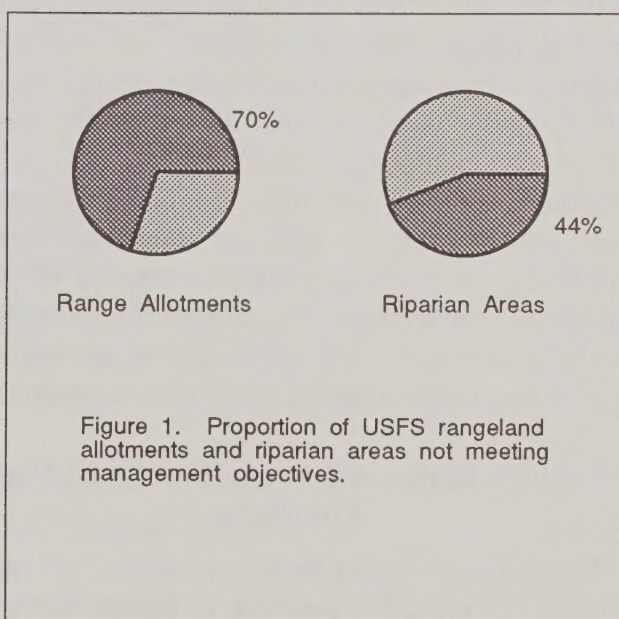


Figure 1. Proportion of USFS rangeland allotments and riparian areas not meeting management objectives.

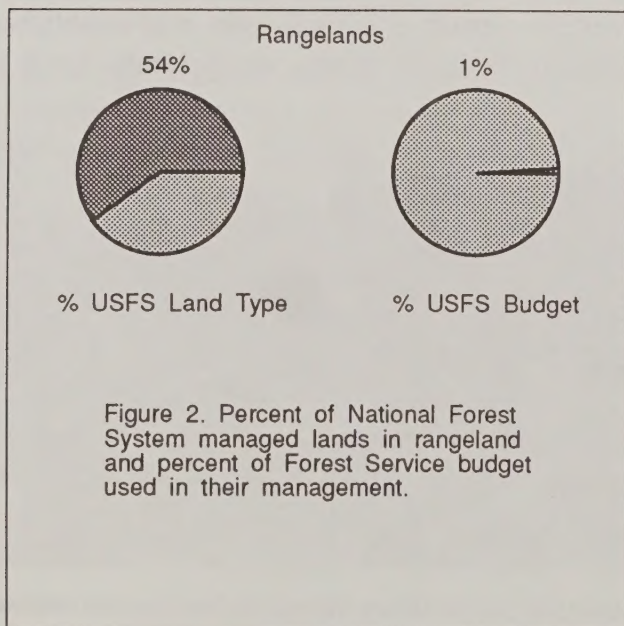


Figure 2. Percent of National Forest System managed lands in rangeland and percent of Forest Service budget used in their management.

## New Perspectives in Rangeland Ecosystem Research

The proposed rangeland research program supports the direction, attitude, and philosophy of the Forest Service "Change On The Range" program and facilitates the delivery of promises made in the 1990 Renewable Resources Planning Act (RPA) Programs. The future focus of rangeland research is the development of a knowledge base on the structure and function of rangeland ecosystems and the conservation of its soil, air, water, vegetation, and wildlife resources. Also, the program must transfer this knowledge to the user groups to increase rangeland productivity in water, wildlife, recreation and livestock values. This program is consistent with



the recommendations of the National Research Council (NRC) of the National Academy of Sciences. The NRC recommended that forestry research adopt an environmental paradigm that focuses on the preservation and enhancement of species, structures, and functions at the stand to landscape levels (NRC 1990). Rangeland research priorities listed by the Research Affairs Committee for the Society for Range Management (1984) also focus on the restoration of rangeland ecological units and improved productivity for multiple rangeland resources.

Inadequate basic information on rangeland species, communities, and rangeland sites limits our ability to understand how ecosystems function and to design management strategies that utilize natural ecosystem processes to maintain themselves. Only by understanding the basic structures and functions of rangeland ecosystems can we effectively design monitoring schemes, evaluate the relationships between water and rangelands, and determine the impacts of integrated management strategies on rangeland ecosystems. To address the emerging rangeland issues described above, an integrated research approach of both applied and *supportive* basic research is needed in the following areas of emphasis:

1. Monitoring rangeland ecosystems.
2. Rangeland watershed interactions.
3. Biodiversity.
4. Integrated wildlife/livestock management strategies.
5. Restoration of rangelands.

The areas of emphasis are in agreement with programs outlined in "Rangeland Research: Past, Present and Future" (Evans 1990). "Stress ecology" programs outlined in the 1990 document have been included here in "Biodiversity," and "Restoration of Rangelands" has replaced the more general topic of "vegetation management".

In addition to developing new information, we need to transfer information and technology already available. Especially in the area of "Restoration of Rangelands," we need to ensure that research results are available to land managers to facilitate the restoration of the 24% of our rangelands currently declining in condition. This area of research and technology transfer should also address grazing



Using a new computer program and current plant cover data, range technicians can quickly convert old range data, such as Parker 3-Step, into a common base for evaluating range condition trends.

management issues in wilderness, riparian zones, and wildlife/livestock use conflicts.

## Can the Forest Service Respond to the Challenge ?

### A Tradition of Providing Solutions to Resource Problems

The Forest Service rangeland research program was created to develop information that would be used to better manage our Nation's rangelands. The Office of Grazing Studies was established in the Forest Service in 1910 to address problems in rangeland readiness, grazing capacity, and forage production. The McSweeney-McNary act of 1928 authorized the Forest Service research program and established the Research Stations. This act was replaced by the Forest and Rangelands Renewable Resources Act of 1978. The current rangeland research program is conducted through the four western Forest and Range Experiment Stations (Appendix A).

Early research by the Office of Grazing Studies and Forest Service scientists was instrumental in initiating the academic fields of Range Management and Range Science. Rangeland research has focused on priority rangeland management issues and made significant



contributions to natural sciences and resource management in the areas of:

- Ecology and range improvement
- Watershed management
- Wildlife and livestock interactions
- Grazing systems
- Plant physiology and genetics
- Economics

### Needs Are Great, Budgets Are Low

Although information needs for rangeland management are greater than ever as we respond to the challenge of the “Change on the Range” program, support for research is the weakest in 20 years. Funding for rangeland research declined from \$5.5 million in 1972 (constant 1991 dollars) to \$3.0 million by 1991, a 55% reduction (Figure 3). The number of rangeland scientists declined by 31% from 1972 to 1989 (Figure 3).

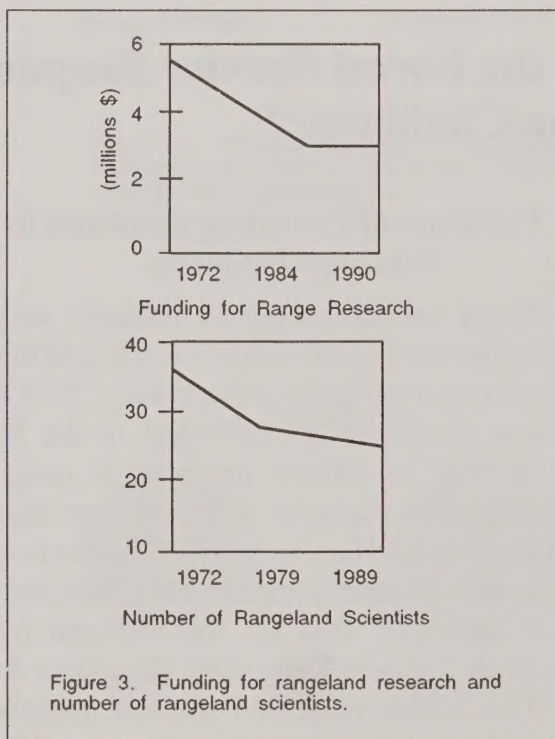


Figure 3. Funding for rangeland research and number of rangeland scientists.

The National Research Council stated that the underinvestment in forestry-related research has limited acquisition of sound biological knowledge and reduced our ability to design sustainable management practices (NRC 1990). Real changes in rangeland management will not occur without

adequate investment in developing new knowledge and technology. The current funding level of \$3.0 million is inadequate to provide the information necessary to resolve user conflicts and reduce degradation of rangeland ecosystems.

If additional funding were made available, the four western Forest and Range Experiment Stations would provide a new research program on “New Perspectives in Rangeland Research”. This program would develop the needed information and technology for the Forest Service and other rangeland managers to meet the challenge of the “Change on the Range” program. The research program to provide a new perspective to rangeland management is outlined below.

## Highlights of the Proposed Research Program

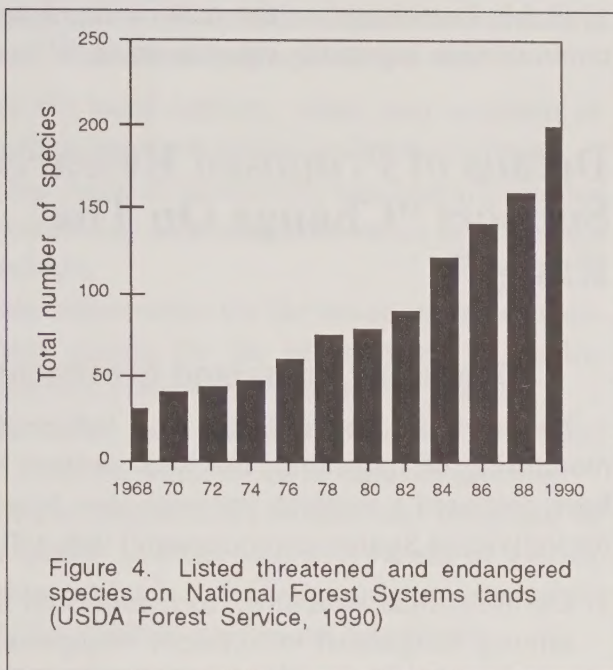
### Monitoring Rangeland Ecosystems

Implementation of forest plans requires intensive monitoring of rangeland resources. New, more accurate and efficient sampling systems need to be developed to monitor critical links in the maintenance of rangeland ecosystems and the production of valued resources. As we monitor more parameters (such as water quality, wildlife habitat, noxious weeds), and increase the percentage of allotments monitored, we will need integrated monitoring schemes that efficiently follow the array of resources and products simultaneously. We need to know what the threshold limits are for maintaining ecosystems such that we can preserve our future management options. Monitoring schemes need to be developed that address not only the individual rangeland site, but its relationship to other landscape components. Methods need to be developed that define resource value ratings for an array of products, and our progress toward the desired rangeland plant community.

### Rangeland Watershed Interactions

To preserve our future options in riparian management, we need to define threshold limits in riparian ecosystem functions. Rangeland watershed research should define the linkage between riparian





and up-slope components. Land managers require information on the permanence of riparian zone improvements under different management strategies.

We need ways to increase availability of on-site water for terrestrial and aquatic wildlife and livestock. To predict the hydrologic consequences of treating uplands to increase water availability, we need information on water use by upland and riparian plant species. We need information on the relationship of riparian systems to groundwater storage and their combined effects on water yield and timing.

We should also address concerns about contamination of water sources, both surface and groundwater, by grazing activities and soil surface pollutants. Resolving conflicts in use between wildlife and livestock requires an evaluation of how both will impact sensitive riparian systems and associated fisheries. Long-term trend studies are needed to document the restoration of currently degraded riparian zones and improvement in condition/trend on all sites (Figure 1).

### Biodiversity

Biodiversity concerns the species, structures, and processes that constitute rangeland ecosystems. Approximately 84% of mammal, 38% of fish, and 58% of amphibian species in the United States are associated with rangeland ecosystems (Joyce 1989).

Major biodiversity issues that face rangeland managers are (1) the restoration of the full complement of shrubs, forbs, and grasses lost from rangeland sites from overgrazing and other disturbances; (2) the increased extent and density of noxious weeds on rangelands; (3) the potential for increased disturbance of rangeland ecosystems from global change; (4) the impact of fire suppression on rangeland ecosystem species composition, structure, and function; and (5) the preservation of threatened, endangered, and sensitive (TES) plant and animal species. The need for increased emphasis on TES species on rangelands is indicated by the continual increase in listed species (Figure 4).

We need to make the ecological and resource linkages among contiguous rangeland sites, and to define the ecological resource roles that rangelands play in relation to other landscape components. Management or treatments applied to a given rangeland site should be evaluated not only as to their effects on the specific site, but also on associated rangeland, forest, and aquatic ecosystems. We need to define how and why rangeland ecosystems disfunction, and the ripple effects that occur through the landscape.

The potential for change in rangeland ecosystems, given global change, is great. We need information on how individual species, communities, range ecosystems, and landscapes will respond to these changes. As rangeland plant communities become environmentally stressed, disturbed ecosystems will be produced. We need to understand these expected changes so we can channel succession to the most desirable rangeland condition rather than let invading and perhaps noxious weeds define future rangeland communities. Riparian systems in arid and semi-arid systems may be especially susceptible to global change.

### Integrated Wildlife/Livestock Management Strategies

Research is needed to investigate the impacts of wild ungulate grazing on rangeland vegetation, soils, and water as numbers of deer and elk are allowed to increase. More accurate information is needed on how big game and livestock utilize rangeland sites and the forage base (Figure 5). An integrated



management strategy needs to be developed to emphasize multi-resource production, including livestock, wildlife, and timber on transitory rangelands. Transitory rangelands are those forest lands that have the potential to produce increased forage for wildlife and livestock during the successional stages after timber harvesting or thinning. Management of such lands is difficult because of the transient nature of the forage base that develops following tree removal and its subsequent decline as the next timber stand develops. Basic research information is needed on the cumulative effects of wildlife, livestock, and timber harvest on the long-term site potential of these transitory rangelands. We need to find ways to reduce livestock/wildlife competition as forage demands of big game increase over time. We need to develop opportunities that capitalize on the matrix of public and private rangelands that provides a much greater potential for improved wildlife habitat and sustainable livestock industry than either alone. Rangeland restoration projects may be required to provide an increased forage base and maintain rangeland site potential under increasing wildlife use.

### **Restoration of Rangelands**

New perspectives in range management call for the re-establishment of diverse rangeland plant communities. We need information on how to establish desirable shrub and forb species in depleted rangelands, especially in riparian zones. The impact of noxious weed invasion of rangelands must be addressed if we are to maintain desirable rangeland communities. A major issue to be resolved is the use of desirable exotic plant species or native species on degraded rangeland sites dominated by exotic weed species.

A coordinated research and technology transfer effort is needed to begin restoring our public rangelands that are in a declining condition. The National Forest System (NFS) estimates that 24% of rangeland allotments it administers are in a declining or overstocked condition (U.S. GAO 1991) and approximately 31% of riparian acres within rangeland allotments are not moving toward a satisfactory condition. An integrated effort between NFS and range scientists is needed to synthesize and apply

available knowledge on the restoration of rangeland communities, especially riparian areas.

## **Details of Proposed Research to Support “Change On The Range”**

### **Monitoring Rangeland Ecosystems**

To meet the demand for new information on monitoring of rangeland, the four western Stations have proposed a research program (see Appendix B for individual Station commitments) that will:

1. Define critical structures, functions, and linkages among rangeland ecosystem components for monitoring in accordance with forest plans.
2. Define a cost-effective sampling procedure to monitor critical links in the maintenance of rangeland ecosystems and the production of resources and products.
3. Develop and link theories about ecological processes with desired resource values to define rangeland site potential, current condition, and resource trends.
4. Design monitoring schemes that establish baseline information on critical rangeland functions and structures, and their subsequent change over space and time.
5. Design monitoring schemes to quantify the quantity and quality of such rangeland product: as water, air, livestock, wildlife, and recreation.
6. Incorporate social and economic values into the decision process for selection of monitoring criteria, monitoring systems, and the interpretation of results to reduce user conflicts.

### **Rangeland Watershed Interactions**

The Stations have proposed a significant research effort that would develop information on riparian zones and associated streams and upland sites. This information will be used by land managers in developing allotment plans, implementing improvement projects, and monitoring of rangeland



riparian resources. As a result of these investments in Rangeland Watershed Interactions, we will:

1. Define the basic nutrient, water, and sediment relationships between upland and riparian sites.
2. Develop methods to establish baseline information on erosion and sediment production in rangeland watersheds.
3. Provide information for the development of management guides for the maintenance of quality riparian ecosystems and associated fisheries.
4. Define basic plant and soil responses associated with livestock/wildlife use of riparian systems.
5. Define the impacts of wildlife and livestock on water quality in areas used by a variety of species.
6. Develop methods to increase on-site water availability for wildlife species on rangelands.
7. Develop information on the use of sensitive riparian plant communities as indicators of channel and floodplain stability.
8. Define the relationship between a riparian plant community, associated water storage capacity, and stream water yield and timing.
9. Reduce user conflicts by incorporating social and economic values into the decision process for management of riparian areas and the associated fisheries.

### **Biodiversity**

The Forest Service has a major concern over the potential loss of plant and animal species. In response to the critical need for information on which to base efforts to preserve and maintain featured threatened, endangered, and sensitive (TES) plant and animal species and maintenance of general rangeland biodiversity, the four western Stations have proposed an ambitious research program that will:

1. Determine the habitat requirements for TES plant and animal species on rangelands.
2. Develop techniques to create or maintain rangelands in a condition suitable for TES populations.
3. Assess population viability for TES species on rangelands.
4. Preserve the genetic pool of TES species and develop methods for increasing their populations

through reintroductions into restored former habitats.

5. Evaluate TES species response to land management activities and opportunities to improve species viability.
6. Establish monitoring guidelines for rare plant and animal species and the community characteristics that most affect their viability.
7. Develop required theory to estimate TES plant and animal species response to global change.
8. Determine causes of noxious weed infestations, and their impact on indigenous species and processes in natural plant communities.
9. Define the role of pioneer disturbance communities on plant succession and long-term site productivity.
10. Define landscape level functions (habitat cover, forage production, and water yield) among adjacent rangeland sites, associated forests, and aquatic systems.

### **Integrated Wildlife/Livestock Management Strategies**

Wildlife/livestock conflicts are a major resource issue on rangelands and have a significant impact on the livestock industry in the 11 western States. To solve conflicts associated with livestock, plant, and wildlife interactions, the Stations have proposed a significant research program (see Appendix B) that will:

1. Provide information on habitat use conflicts among elk, deer, and livestock on rangelands.
2. Define the impacts of increased big game use on other wildlife species.
3. Develop systems to evaluate the separate and combined impacts of livestock and wildlife use on rangeland plants, water, and soils.
4. Define livestock, wood fiber, and wildlife productivity levels for transitory rangelands.
5. Define the process by which rangeland plant communities accumulate and cycle carbon and nitrogen, and demonstrate how this relates to both the quantity and quality of water, wildlife, and livestock productivity.
6. Define opportunities to utilize livestock to improve wildlife habitat.



7. Reduce user conflicts by incorporating social and economic values into the decision process for rangeland resource allocation among livestock, wildlife, and timber.

### Restoration of Rangelands

New research information and technology transfer are needed to restore the 24% of our rangeland allotments that are in an unsuitable and declining condition. To facilitate rangeland improvement and meet the increasing demands for use of our rangelands, the Stations propose a program of research that will:

1. Coordinate with other land management agencies to implement and evaluate rangeland restoration techniques, especially those for riparian systems, that would restore unsatisfactory rangeland allotments and meet management objectives.
2. Increase the development, application, and information transfer efforts on recommended grazing systems and rangeland restoration techniques.
3. Cooperatively implement large-scale restoration projects in coordination with land management agencies to reintroduce desirable native or introduced grasses, shrubs, and forbs in rangelands.

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# Appendix A

## Rangeland Research Locations

### *Intermountain Research Station*

INT-4202

Proj. Leader: W. Clary

Location: Boise, ID

Mission: Develop an understanding of riparian and stream habitats for improved management for conservation of resources and the production of livestock, wildlife, and fish.

INT-4251

Proj. Leader: D. McArthur

Location: Provo, UT

Mission: Develop improved plants and the necessary technology for their production, establishment, and management on rangelands and disturbed habitats.

INT-4252

Proj. Leader: R. Tausch

Location: Reno, NV

Mission: Determine ecological processes in Great Basin pinyon-juniper ecosystems, emphasizing the effects of management activities and global change.

INT-4253/4801

Proj. Leaders: G. Booth/D. Van Hooser

Location: Ogden, UT

Mission: Develop survey/monitoring technology and habitat management models to assess non-timber values and trends.

### *Rocky Mountain Forest and Range Experiment Station*

RM-4251

Proj. Leader: K. Severson.

Location: Tempe, AZ

Mission: Develop management strategies on fish and wildlife habitats for southwestern forests and rangelands.

RM-4252

Proj. Leader: D. Uresk

Location: Rapid City, SD

Mission: Develop and improve technology to optimize livestock-wildlife outputs and maintain biological diversity.

RM-4351

Proj. Leader: E. Aldon

Location: Albuquerque, NM

Mission: Create information needed to rehabilitate and improve productivity and stability of semi-arid lands in the Southwest.

### *Pacific Northwest Research Station*

PNW-4357, PNW-4551

Sci. Team Leaders: J. Thomas, T. Quigley

Independent Sci.: A. Tiedemann

Location: LaGrande, OR

Mission: Assess responses and interactions among deer, elk, timber, and cattle to intensive forest management in forested rangelands, and protect rangeland habitats.

PNW-4252

Sci. Team Leader: R. Everett

Location: Wenatchee, WA

Mission: Ecosystem management for sustained rangeland resource productivity and biodiversity.

### *Pacific Southwest Research Station*

PSW-4202

Proj. Leader: J. Verner

Location: Fresno, CA

Mission: Address cost-effective monitoring of wildlife populations and characterization of grazing impacts on montane riparian zones.



## Appendix B

### Individual Station Commitments

The Forest Service rangeland research program is being conducted by scientists in our four western Experiment Stations:

- INT Intermountain Research Station (Idaho, Montana, Nevada, Utah, and western Wyoming)
- PNW Pacific Northwest Research Station (Alaska, Oregon, and Washington)
- PSW Pacific Southwest Research Station (California and Hawaii)
- RM Rocky Mountain Forest and Range Experiment Station (Arizona, Colorado, Kansas, Nebraska, New Mexico, North Dakota, South Dakota, Texas, and Wyoming)

Individual Station proposals for future rangeland research are listed below under each of the five research areas identified as emerging issues for these ecosystems.

### Monitoring Rangeland Ecosystems

- PSW: Describe monitoring systems that utilize multivariate and quantitative ecological methods to define and track the status of rangeland sites as related to management objectives and potential natural vegetation.  
  
Evaluate and validate monitoring systems that are most efficient and statistically viable for defining and tracking rangeland status as related to management objectives and potential natural vegetation.
- INT: Strengthen statistical methods to monitor rangeland resource trends and management impacts effectively.  
  
Develop and conduct workshops to provide resource managers with practical tools to meet rangeland resource monitoring requirements.  
  
Determine statistical methods appropriate to monitor small populations, i.e. threatened,

endangered, and sensitive plant and animal species.

Develop protocols and incorporate non-timber resource measurements into rangeland survey procedures.

- PNW: Explore and test new and existing techniques for taking uniform, rapid, repeatable, on-the-ground measurements that assess soil and vegetation conditions and change over time.

Establish usable linkages between on-the-ground measurements and aerial or satellite imagery for ground cover, soil conditions, plant phenology, and herbage and browse use.

Devise the techniques required to separate climatic and management-induced changes in vegetation and soil.

- RM: Develop techniques to monitor changes in rangeland status resulting from anthropogenic activities and natural stress events on Great Plains and Southwestern rangelands.

### Rangeland Watershed Interactions

- PNW: Determine how to integrate upland and riparian grazing patterns into a strategy to minimize adverse effects on soil stability and stream water quality.  
  
Measure soil stability and water quality changes associated with the development and use of transitory ranges.  
  
Find ways to reduce impacts of livestock grazing on sediment production, turbidity, and bacterial water quality to levels consistent with State and Federal water quality standards.  
  
Assess the effects of grazing-associated water quality changes on stream biota and food chains.  
  
Determine the role of catastrophic events (ice flow, fire) on riparian vegetation.  
  
Explore alternatives to conventional fencing,



such as electronic livestock control, for managing livestock use in riparian areas.

Develop cost-effective technology for riparian habitat restoration.

Determine threshold values for riparian structures and processes that respond to ungulate grazing pressure.

**PSW:** Describe the kinds of wildlife habitats in, pollution sources to, and best management practices for riparian areas in annual-grass foothill rangeland of central California.

**INT:** Improve basic knowledge of riparian structure, function, and contribution to landscape diversity.

Identify or develop management practices compatible with riparian area values and sensitivities.

Develop a better understanding of the hydrologic regime of riparian systems, emphasizing degraded and de-watered systems.

Develop tools for prediction of effects of sediments and other habitat changes, including changes in riparian conditions, on fish productivity in streams.

**RM:** Develop an understanding of natural and management-induced changes in soil/plant/water interactions along hydrologic, climatic, and elevational gradients and their effects on long-term rangeland productivity.

### **Biodiversity**

**RM:** Develop a better understanding of how disturbances, both natural and induced, influence ecological succession, wildlife-habitat interactions, and rangeland ecosystems.

Develop an understanding of soil/plant productivity relationships on rangelands, and determine both optimal and threshold grazing levels to maintain soil condition and plant productivity.

**PNW:** Determine basic ecological requirements of

TES plant species and unique habitats, and develop management prescriptions for these species and their habitats.

Define the impacts of noxious weeds on indigenous rangeland plant species, rangeland communities, and functions.

Define expected composition and structure changes of rangelands at the forest-grassland interface in response to global change.

**PSW:** Determine ecological factors that limit the growth and reproduction of threatened, endangered, and sensitive plant species, and how these factors can be manipulated to maintain viable plant populations.

Determine the compatibility of the biodiversity concept and range condition concept.

**INT:** Develop recovery strategies for threatened, endangered, and sensitive rangeland species.

Evaluate the relationships between the patterns of community changes and changes in climatic factors, species introductions, and land use activities, especially for pinyon-juniper and riparian systems.

Determine interactions among aquatic species, herbivory, and recreation uses.

Develop achievable standards for "desired future condition" based on site productivity and current species compositions.

Contrast factors leading to increased species diversity compared to increased genetic diversity of rangeland plant communities.

### **Integrated Livestock/Plant/Wildlife Management Strategies**

**INT:** Determine changes in elk habitat use related to resource management actions (such as livestock grazing and recreation use).

Assess impacts of big game populations on success of riparian restoration projects and develop effective management strategies.

Develop the information necessary for de-



veloping best grazing management practices and desired future condition standards for land management alternatives.

Develop strategies for livestock/big game management on high mountain meadows that will maintain and/or improve site integrity.

Assess impacts of domestic and recreational livestock in wilderness ecosystems, and develop recommendations for management of livestock in these areas.

**RM:** Develop and test methods of allocating finite rangeland resources among domestic and wild animals, and assess the resultant interactions and impacts on rangeland condition.

Develop a better understanding of how livestock and big game animals influence the dispersal of desirable and undesirable plant species on rangelands and assess impacts.

Determine whether livestock could be used to manage vegetation in a positive and directed fashion, and the quantity and quality of forage that can be expected for lands managed in this fashion.

**PSW:** Determine how livestock grazing management strategies can effectively enhance meadow and associated riparian habitats for wildlife and TES plants in the Sierra Nevada.

Determine the vegetative and soil characteristics of riparian meadows and stream ecosystems in Sierra Nevada and Cascade ranges that are most susceptible to damage from livestock trampling and grazing.

Explore ways to focus the concerns of a wide variety of rangeland users in such a way as to improve rangeland management.

**PNW:** Evaluate nutrient cycling and soil fertility consequences of grazing transitory ranges from the standpoint of future forest productivity and continued forage productivity.

Elucidate the long-term effects of large un-

gulates (domestic and wild) on forest succession, tree recruitment, and total site productivity.

Develop techniques to optimize forage production for wild and domestic ungulates, but not interfere with tree establishment and growth.

Find ways to graze transitory rangelands so that the productivity of other resources on these lands, including timber production, is maintained or enhanced.

Assess the effects of grazing transitory rangelands on big game wildlife habitats and food resources.

Assess the response of deer, elk, and cattle to intensive forest management and associated wildlife/livestock interactions.

Determine response of deer, elk, and cattle to different road densities and traffic intensities.

Determine animal unit equivalencies (AUE) among deer, elk, and cattle on summer ranges.

Determine the economic consequences of various options for developing transitory rangelands in terms of the gains in forage productivity, livestock outputs, forage availability to deer and elk, timber production, and the maintenance or enhancement of habitats for other wildlife species.

Reduce user conflicts by incorporating social and economic values into the decision-making process for allocation of rangelands among the potential uses.

Define adverse impacts of wildlife to riparian soil and vegetation resources.

### **Restoration of Rangelands**

**PNW:** Find ways to establish forbs and shrubs on transitory rangelands to promote forage resources and enhance natural forest succession processes.





Increase technology transfer efforts to ensure research results are made available to user groups through a variety of techniques, including site visits, workshops, training sessions, and articles in both popular and scientific journals.

**RM:** Synthesize existing information on rangeland research findings for use in developing management practices that minimize conflicts between resource uses.

Develop recommendations for non-chemical control of snakeweed and woodland species invading grasslands in the Southwest.

**PSW:** Develop recommendations for the best vegetation management practices for preventing wildfire and watershed damage at the wildland-urban interface in California's annual-grass foothill rangelands.

**INT:** Develop reliable, cost-effective rangeland rehabilitation prescriptions.

Evaluate and demonstrate the use and performance of selected plant materials for restoration and improvement of rangelands.

Develop and demonstrate methods of predicting restoration "potentials", in time and cost terms, for degraded rangeland systems.

Develop autecological information on important riparian species as a basis to improve understanding of regenerative capabilities of riparian communities and improve management prescriptions.



